This revision supersedes Public Health Service Publication No. 791 (Revised) published in February 1962 under the same title.

Public Health Service Publication No. 930-D-23
March 1968

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402 - Price 30 cents

FALLOUT PROTECTION for HOSPITALS

U.S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE

Division of Hospital and Medical Facilities
Architectural, Engineering, and Equipment Branch
Silver Spring, Maryland 20910

ACKNOWLEDGMENTS

This project was developed by the staff of the Architectural, Engineering, and Equipment Branch, Division of Hospital and Medical Facilities, Public Health Service, U.S. Department of Health, Education, and Welfare.

Detailed engineering analyses related to the mechanical, electrical, structural, and fallout protection phases of the project were performed by Peter W. Bruder, Consulting Engineer, New York, N.Y.

Robert Berne was project officer for the Office of Civil Defense and Julian E. Smariga was project officer for the Division of Hospital and Medical Facilities.

FOREWORD

This publication was developed by the Hill-Burton Program of the Public Health Service, under a grant from the Office of Civil Defense, Department of Defense. It presents the findings of continuing studies to develop principles for the design of hospitals offering protection from the effects of gamma radiation resulting from fallout of a nuclear explosion.

The studies reveal the feasibility of incorporating special measures to protect patients, personnel, and vital functional components within the facility. Moreover, it was found that such construction could be carried out at a reasonable cost.

This project fulfills the requirements of Executive Order 11001 for the Department of Health, Education, and Welfare to provide guidance material, adapted to the needs of hospitals, in methods of disaster preparedness and control.

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Assistant Surgeon General
Director, Division of Hospital
and Medical Facilities

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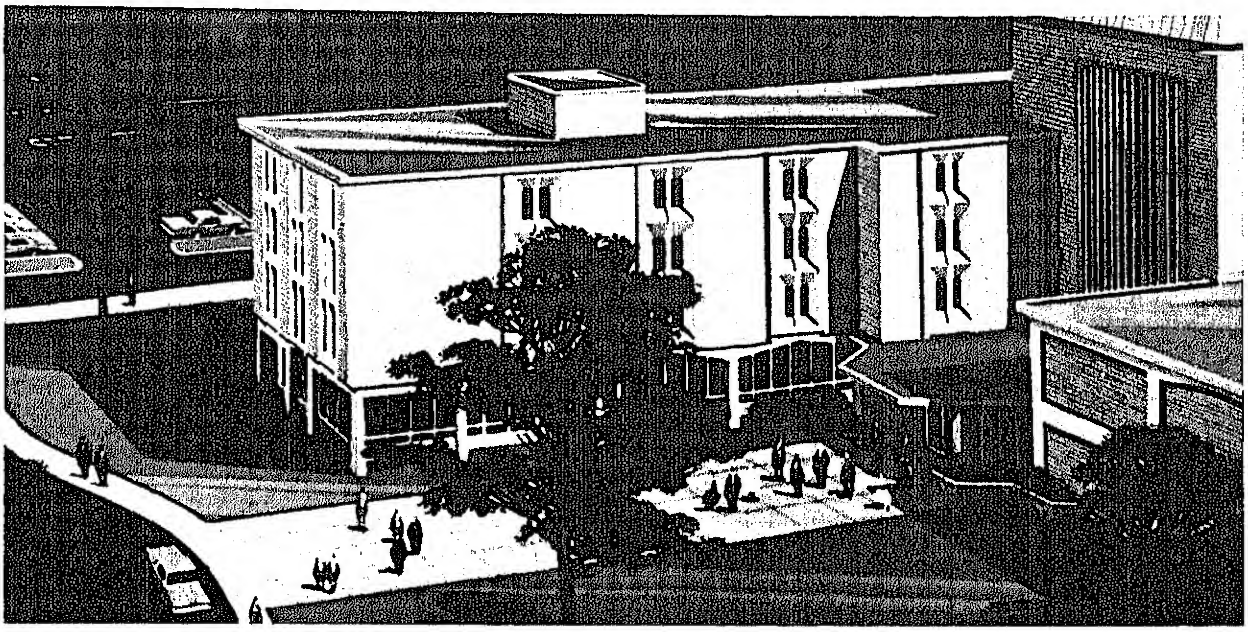

INTRODUCTION

The Public Health Service, in keeping with its responsibility for protecting and improving the Nation's health, has for many years been interested in the problems facing hospitals in the event, no matter how remote, of a nuclear attack. In addition to providing continuing care and shelter for patients and personnel during an emergency, the hospital must strive to preserve basic services and facilities for prompt use following the attack period. Efficient service, an important adjunct to the rapid recovery and rehabilitation of a community struck by any disaster, is especially vital following a nuclear attack.

The detonation of a nuclear weapon produces four major effects--blast, heat, initial nuclear radiation, and the residual radioactivity of fallout. The first three effects will be limited to an area surrounding the detonation, and only facilities in the target zone will be subject to these effects. The fourth could affect as much as 76 percent of the total area of the country in the event of a widespread nuclear attack. The areas not affected, however, are unpredictable and subject to daily change because of weather conditions.

President Johnson has said: "It is clear that, without fallout protection for our citizens, all defense weapons lose much of their effectiveness in saving lives. This also appears to be the least expensive way of saving lives and the one which has clear value even without other systems."

The Department of Defense has echoed this same opinion and enlarged upon it, placing civil defense in context with the defense of the Nation. A statement from the Department noted: "Three major programs constitute our general nuclear war forces; (1) the strategic offensive forces, (2) the continental air and missile defense forces, and (3) civil defense. Analysis clearly demonstrates the distinct utility of a nationwide fallout shelter program in reducing fatalities at all levels of attack. Fallout shelters should have the highest priority of any defense system because they decrease the vulnerability of the population to nuclear contamination under all types of attack. No other system of defense will protect as many people from the fallout radiation threat at so small an expense as will a shelter system."

To assist in carrying out this established policy, the Public Health Service previously collaborated with the Office of Civil Defense (OCD), Department of Defense, to develop general criteria and standards for protective measures in hospitals. This information is given in the appendix, p. 23 and is published by OCD as Technical Memorandum 65-1, Technical Requirements for Fallout Shelters in Hospitals. The practical application of these guidelines to the design of a prototype hospital is discussed in this publication.

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GENERAL CONSIDERATIONS

A hospital in the 150- to 200-bed capacity range was selected for this design study for two principal reasons. First, this is generally agreed to be the optimum size for illustrating the complex problem of departmental relationships and hospital communications in conjunction with the essential features of civil defense protection without obscuring the obvious characteristics of either. This guide could be used by architects of larger or smaller hospital facilities with minimum adaptation and interpolation. Second, it is becoming apparent that hospitals of this capacity range are typical of those likely to be built--in fact they are being built--outside the perimeters of urban communities. Hospitals of this type, spared the destructive effects of blast and heat, could still be subjected to fallout radiation.

The following broad guidelines were established to assist in the development of the project:

(1) The hospital should be well designed in accordance with current functional planning and design criteria. It should be designed to operate in a conventional manner as a general hospital fulfilling the health needs of an average community and should reflect the best current thinking in overall pattern and details. The size relationship of the various departments should present an idealized general solution which could be varied readily to satisfy the needs of the community in which the hospital is to be built. It should be identifiable as a good hospital plan, whether or not it is to be built with the fallout radiation protection features.

(2) The protective measures should be incorporated in the design in a manner that will not detract from the normal functions. Every effort should be made to provide an efficient and economical facility from the viewpoint of normal day-to-day operation. The dual-purpose fallout shelter requirement shall not adversely affect any hospital function.

(3) Consideration should be given to the maximum utilization for shelter of available hospital services and spaces. For greatest economy in design and construction, space and equipment provided exclusively for civil defense purposes (see appendix) should be kept to a minimum. All suitable space in the hospital should be considered available for shelter use during the emergency period. Shelter space in excess of that required for hospital purposes should be made available for the public. If equipment vital to the operation of the shelter is used in the normal operation of the hospital (such as an emergency generator), its reliability in time of emergency would be of a high order.

(4) The design should meet the requirements of national building codes and regulations to demonstrate the complete practicality of incorporating fallout protection in the design of hospitals. This implies that nursing units should not be placed in a windowless structure because building codes do not permit a patient room to be so located. Similarly, exit facilities, mechanical equipment, and other elements controlled by building codes should conform to national standards and satisfy the functional requirements of normal everyday use.

(5) If possible, the protective features of the resulting design should be readily apparent, although not in a disquieting fashion. Because this project is to serve as a prototype, the fallout protection measures are well defined and easily assimilated.

(6) The design should be as up to date and attractive as possible and the project should appear to be as conventional as possible. Because this is to be a general hospital that can be built for everyday use, wholehearted acceptance by the community might be jeopardized if the resulting building were to be significantly different from standard design.

THE HOSPITAL PLAN

The site plan (see fig. 1) is designed to separate service traffic from staff, employee, visitor, and emergency traffic. Convenient parking is provided for visitors near the main entrance and, if necessary, additional parking can be accommodated in the employee and staff main parking area at the side. The judicious use of landscaping and tree planting can serve to minimize street noise and dust as well as to improve the patients' views.

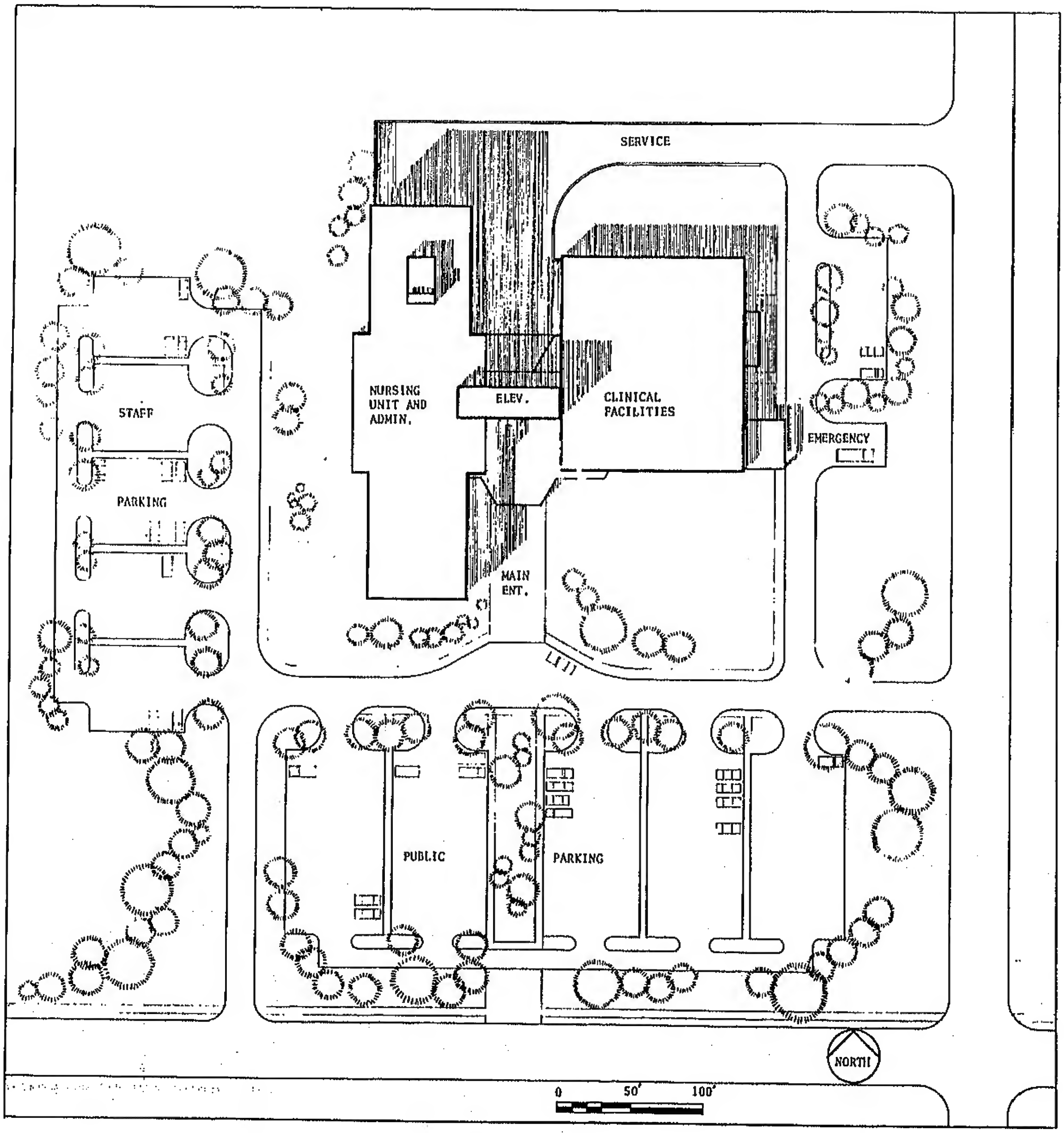


Figure 1. Site plan.

The hospital is composed of three distinct units: a patient unit, a clinical services unit, and an interconnecting circulation unit. The patient unit and the circulation unit are four stories high and are of conventional construction. The clinical services unit is two stories high, is practically windowless, and is designed with a minimum number of other openings. Only hospital elements with functions or uses which would not be jeopardized in any manner by being located in a windowless environment are contained in this unit. Long span construction, permitting a minimum number of interior columns and lighweight partitions, is used to provide maximum flexibility in the arrangement of the various departments. The ground floor is below grade at the front but opens to grade at the rear.

The ground floor contains the service entrance, employees' facilities, boiler room, maintenance shops, dietary services, laundry, central sterilizing and supply areas, storage rooms, and the autopsy suite. (See fig. 2.) These services are frequently located at the ground level or underground with limited exterior wall opening.

The first floor of the patient and circulation units contains the main entrance lobby, the administration department, staff doctors' facilities, and a self-care patient unit, all conveniently accessible from the street and parking areas. The

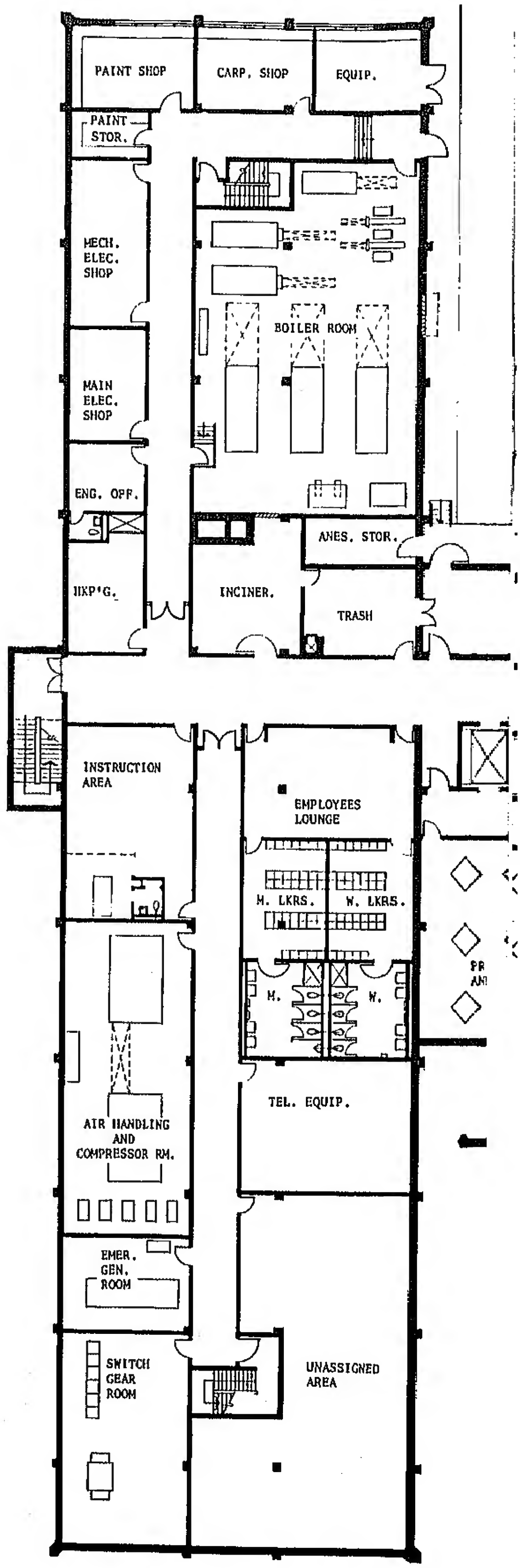
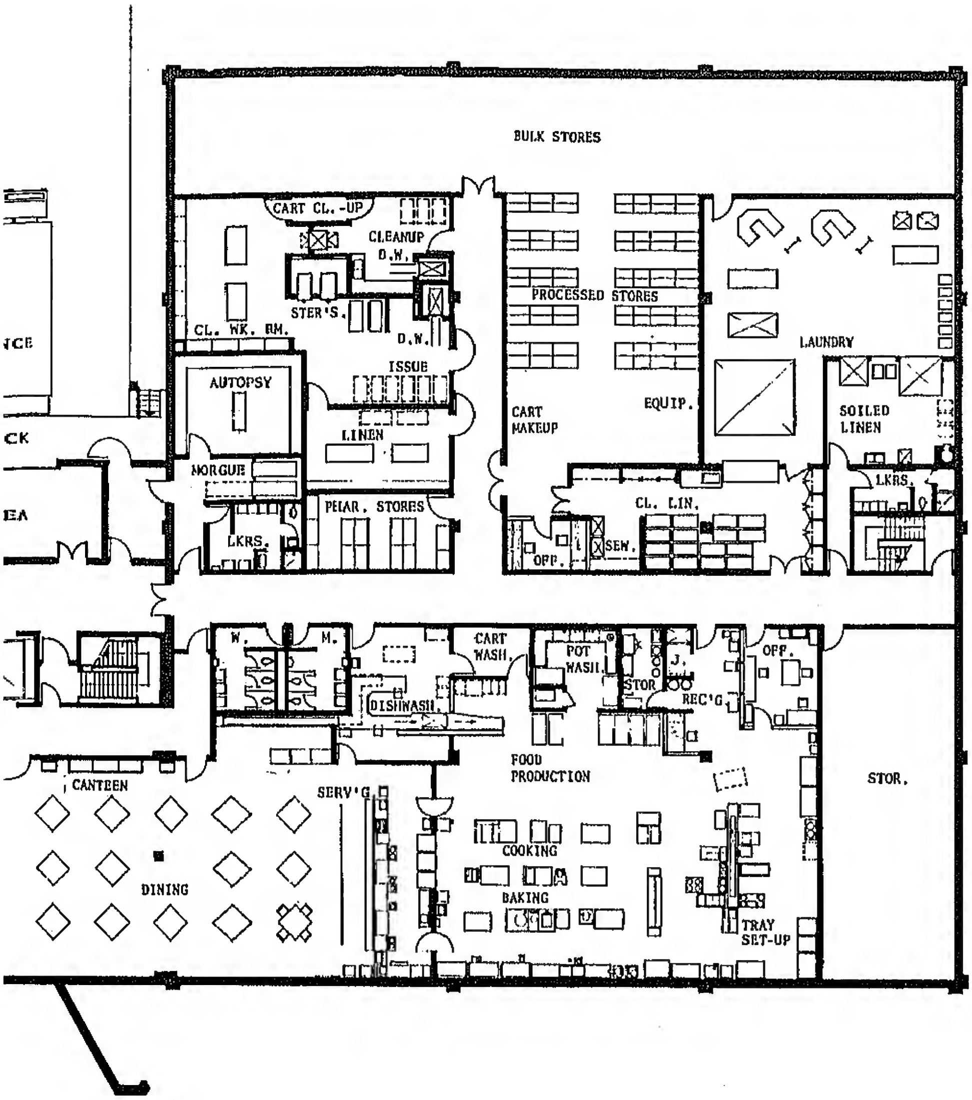


Figure 2. Ground floor plan.



BULK STORES
CART CL.-UP
CLEANUP
D.W.
STER'S.
D.W.
CL. WK. RM.
ISSUE
AUTOPSY
LINEN
MORGUE
PHAR. STORES
LKRS.
PROCESSED STORES
CART
MAKEUP
EQUIP.
CL. LIN.
OFF.
SEW.
LAUNDRY
SOILED
LINEN
LKRS.
W.
M.
CART
WASH
POT
WASH
STOR
J.
REC'G
OFF.
DISHWASH
FOOD
PRODUCTION
CANTEEN
SERV'G
COOKING
BAKING
DINING
TRAY
SET-UP
STOR.
NCE
CK
EA

first floor of the clinical services unit contains the outpatient facilities, the emergency department, X-ray department, pharmacy, laboratory, and the physical therapy unit. (See fig. 3.) The concept of placing such clinical and diagnostic areas in a windowless structure has been widely accepted.

The second floor of the clinical services unit contains the delivery suite and the surgical suite. (See fig. 4.) The three upper floors of the patient wing contain all the nursing units. (See figs. 5 and 6.) The prime reason for locating the nursing units in a section of the building of conventional construction is to comply with current building codes that contain restrictions against windowless patient rooms. Moreover, at this time, there is a widespread public antipathy to the idea of windowless rooms. Therefore, because it was possible to provide adequate shelter space for hospital purposes without resorting to the use of the patient areas, this solution is considered desirable.

The relationships of the various hospital departmental areas are graphically illustrated in the section shown in fig. 7.

For shielding purposes, the number of openings into the clinical services unit, which is planned to be the hospital shelter area in time of nuclear disaster, is limited to the minimum needed for nor-

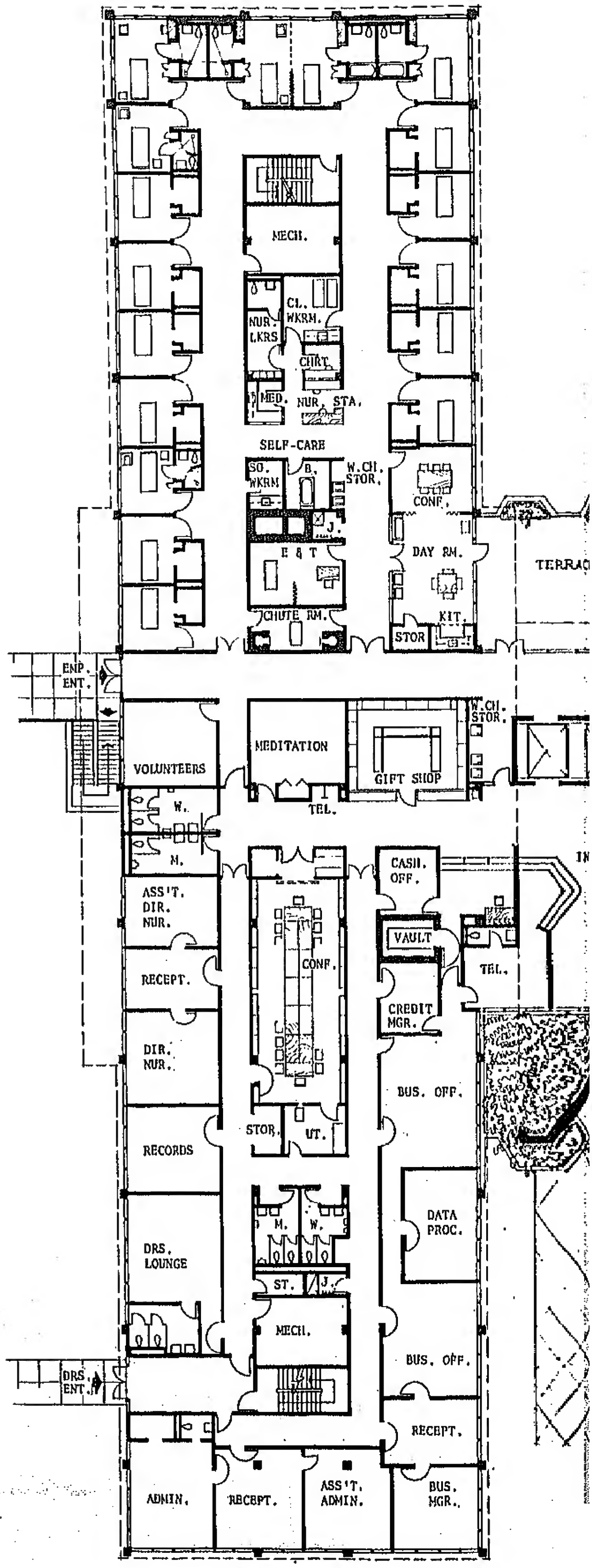
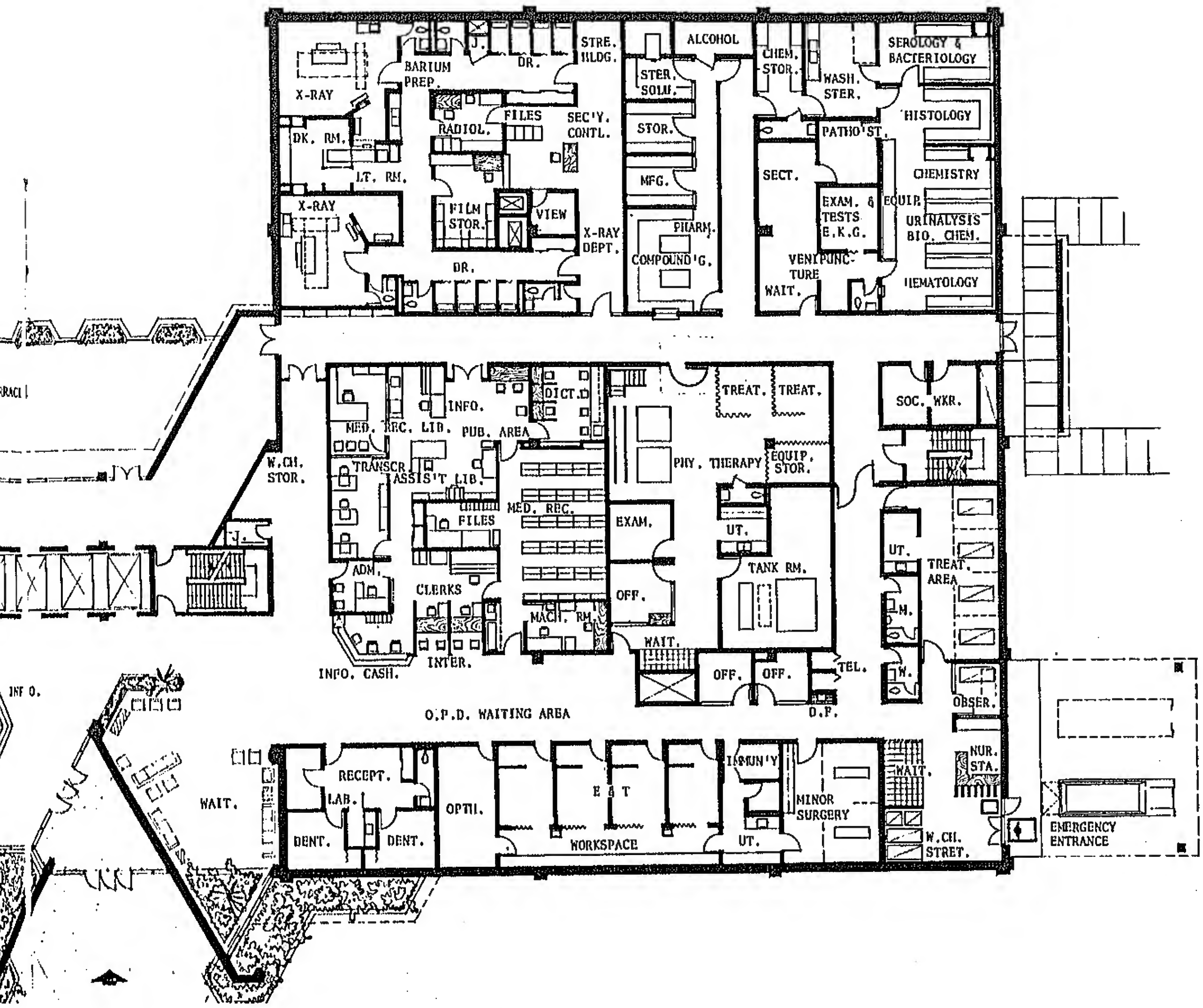


Figure 3. First floor plan.



X-RAY
BARIUM PREP.
J.
DR.
STRE. HLDG.
ALCOHOL
CHEM. STOR.
WASH. STER.
SEROLOGY & BACTERIOLOGY
DK. RM.
RADIOL.
FILES
SEC'Y. CONTL.
STER. SOLU.
STOR.
PATHO'ST.
HISTOLOGY
LT. RM.
MFG.
SECT.
CHEMISTRY
X-RAY
FILM STOR.
VIEW
X-RAY DEPT.
PHARM.
COMPOUND'G.
EXAM. & TESTS E.K.G.
EQUIP.
URINALYSIS BIO. CHEM.
DR.
VENIPUNC-TURE
WAIT.
HEMATOLOGY
INFO.
DICT.
TREAT.
TREAT.
SOC. WKR.
MED. REC. LIB.
PUB. AREA
W.CH. STOR.
TRANSCR.
ASSIS'T LIB.
PHY. THERAPY
EQUIP. STOR.
FILES
MED. REC.
EXAM.
UT.
UT.
TREAT. AREA
ADM.
CLERKS
TANK RM.
OFF.
M.
MACH. RM.
INFO. CASH.
INTER.
WAIT.
OFF.
OFF.
TEL.
W.
INFO.
O.P.D. WAITING AREA
D.F.
OBSER.
RECEPT.
IMMUN'Y
WAIT.
NUR. STA.
WAIT.
LAB.
OPTH.
E & T
MINOR SURGERY
DENT.
DENT.
WORKSPACE
UT.
W.CH. STRET.
EMERGENCY ENTRANCE

mal functional use. On the first floor is a public entrance to the outpatient department with ready access to X-ray, pharmacy, laboratory, and physical therapy. The emergency department, which must be conveniently accessible to the public street, has one entrance located and arranged to minimize the entry of direct radiation into the building. Another entrance provides access to the clinical services for inpatients and staff. The first floor also contains an exit door shielded by a baffle wall for use in case of fire emergencies. The ground floor has a public entrance to the dining facilities, a service entrance to the supply and housekeeping areas, and a separate door to the morgue and autopsy suites.

During the period of a radiation fallout emergency, all main doors to the hospital shelter can be closed, and access to and egress from this area, if necessary, will be through the autopsy entrance. This entrance is arranged with suitable washing facilities for radiological decontamination of individuals who may have been subjected to the fallout environment. (This, however, is not part of the OCD technical requirements.)

Future expansion is another important feature that was considered. The arrangement shown will permit lateral expansion in three directions for increasing the clinical areas and service departments. Future patient units should logically be placed over the existing patient wings.

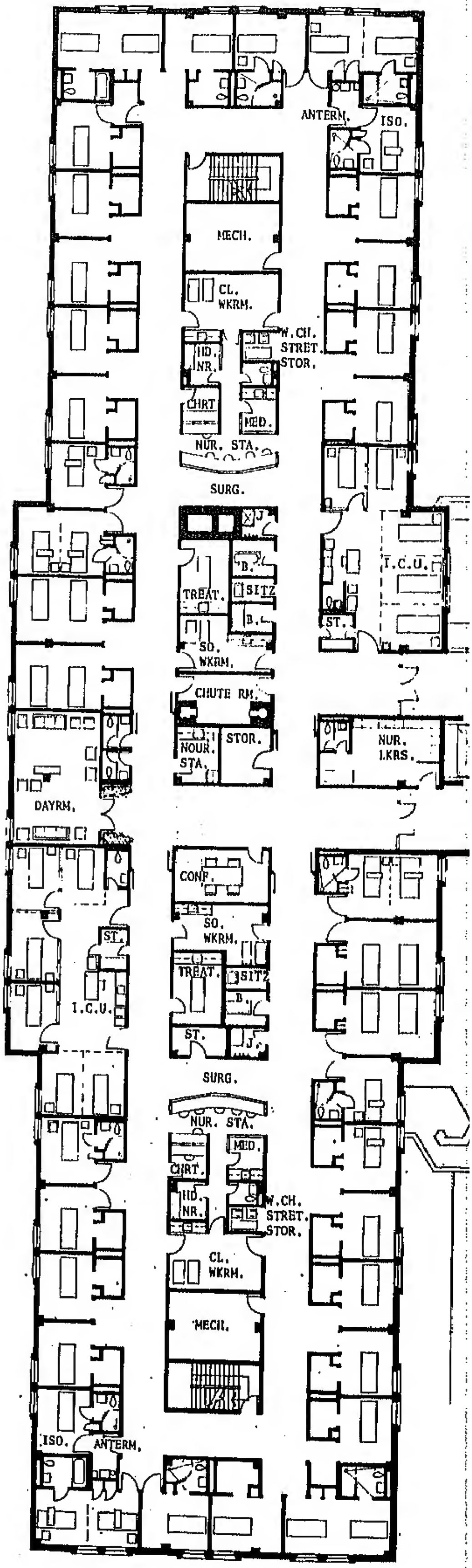
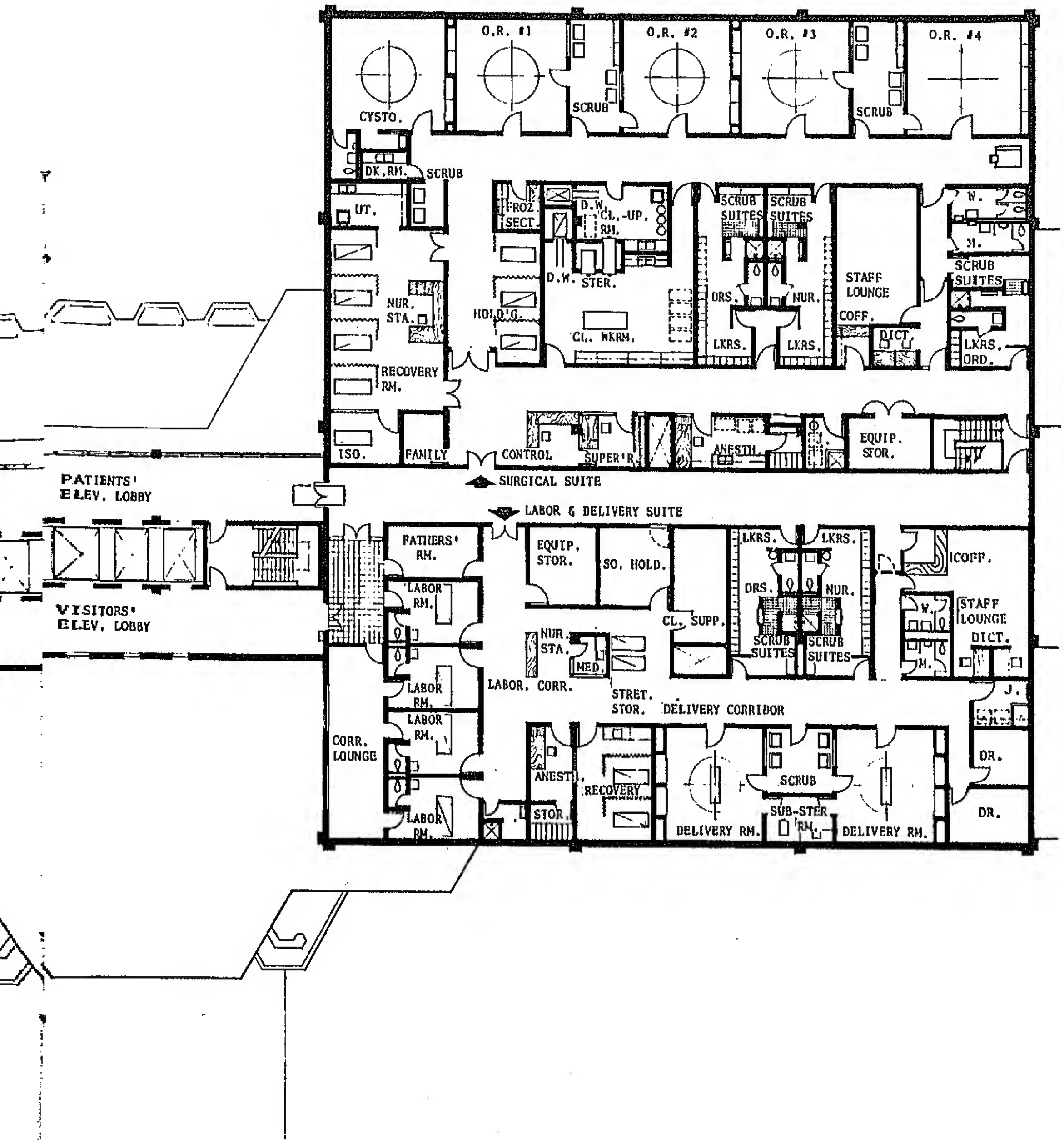


Figure 4. Second floor plan.



O.R. #1
O.R. #2
O.R. #3
O.R. #4
CYSTO.
SCRUB
SCRUB
DK.RM.
SCRUB
UT.
NUR. STA.
RECOVERY RM.
ISO.
FAMILY
FROZ. SECT.
D.W.
CL.-UP. RM.
D.W. STER.
HOLD'G.
CL. WKRM.
SCRUB SUITES
SCRUB SUITES
DRS.
NUR.
LKRS.
LKRS.
STAFF LOUNGE
COFF.
DICT.
W.
M.
SCRUB SUITES
LKRS. ORD.
CONTROL
SUPER'R
ANESTH.
EQUIP. STOR.
SURGICAL SUITE
LABOR & DELIVERY SUITE
PATIENTS' ELEV. LOBBY
VISITORS' ELEV. LOBBY
FATHERS' RM.
LABOR RM.
LABOR RM.
LABOR RM.
LABOR RM.
CORR. LOUNGE
EQUIP. STOR.
SO. HOLD.
CL. SUPP.
NUR. STA.
MED.
LKRS.
LKRS.
DRS.
NUR.
SCRUB SUITES
SCRUB SUITES
COFF.
W.
M.
STAFF LOUNGE
DICT.
LABOR. CORR.
STRET. STOR.
DELIVERY CORRIDOR
J.
DR.
DR.
ANEST.
RECOVERY
STOR.
SCRUB
SUB-STER RM.
DELIVERY RM.
DELIVERY RM.

Figure 5. Third floor plan.

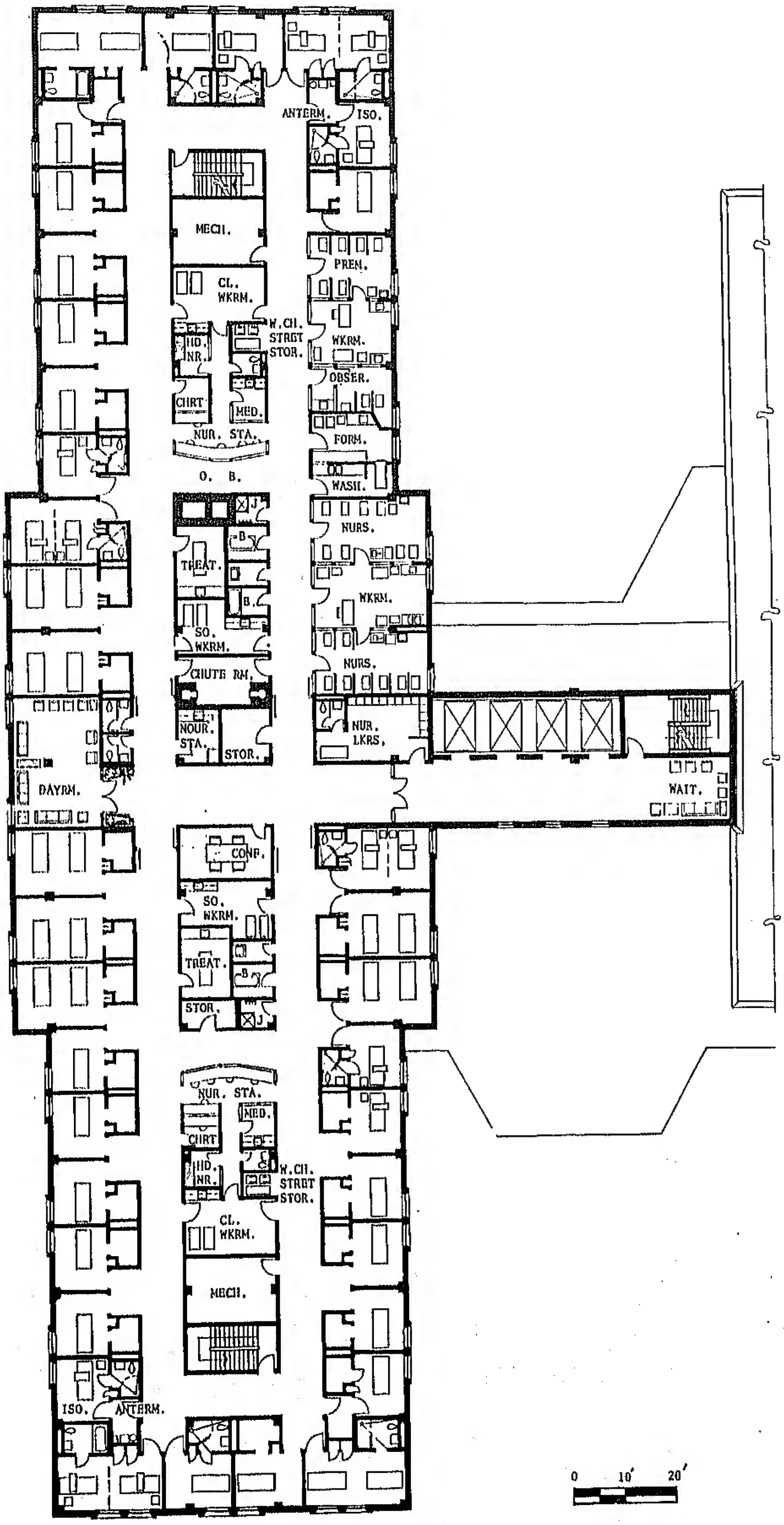


Figure 6. Fourth floor plan.

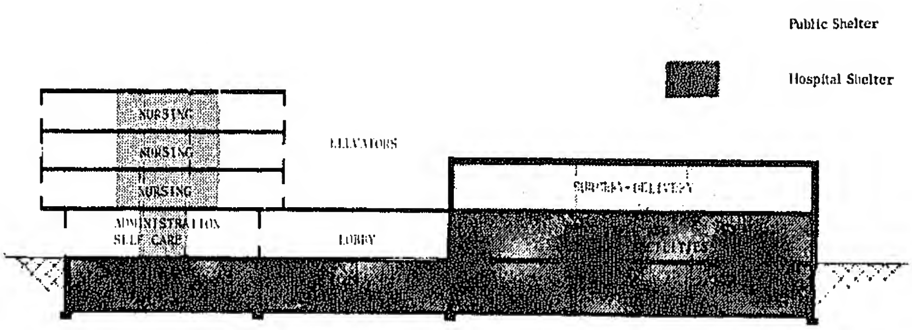


Figure 7. Section showing relationship of various hospital departmental areas.

SHELTER SPACE

In the event of nuclear attack, under normal weather conditions, significant amounts of fallout are not expected to arrive outside the blast area before approximately one-half hour after the explosion. It is reasonable to assume, therefore, that a hospital not located in a blast area, if promptly notified of an attack, would have time to prepare for the fallout emergency.

Based on this assumption, a limited, but adequate, time would be available for the movement of patients and staff from their normal locations to the best available shelter space in the hospital. Based on the technical requirements for fallout shelters in hospitals given in the appendix, p. 23, the optimum shelter areas in the prototype plan are shown in figures 8 through 11.

Upon warning of a nuclear attack, all patients, staff, and others in the patient and circulation units of the hospital would be evacuated to the shelter areas in the windowless clinical service unit. The mechanical and electrical systems would be switched over to the preplanned civil defense emergency operating conditions. When all other emergency preparations are completed, cots would be set up to accommodate the number of persons to be sheltered. Although it is impossible to predict, it is assumed that the fallout emergency may last as long as two weeks, and sufficient fuel, food, and other supplies should be stored for this interval (see appendix).

Because an attack may occur at any time of the day or night, the hospital should be prepared to

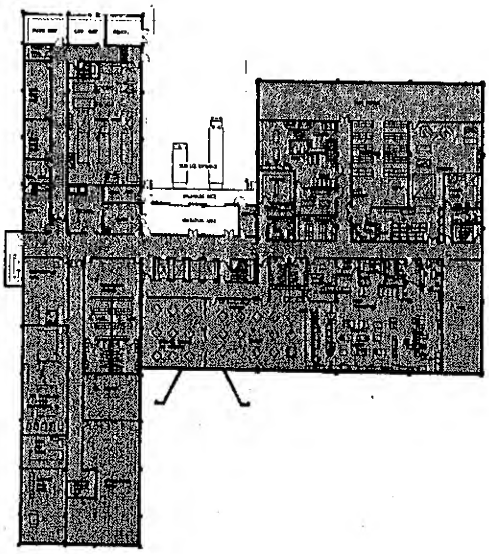


Figure 8. Hospital shelter area on ground floor.

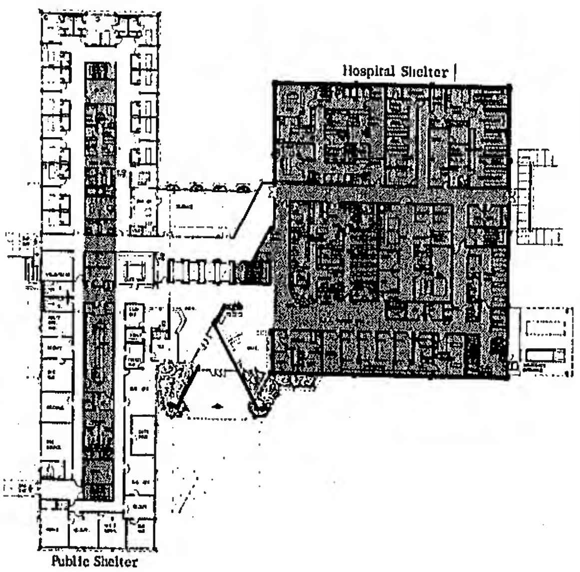


Figure 9. Hospital and public shelter areas on first floor.

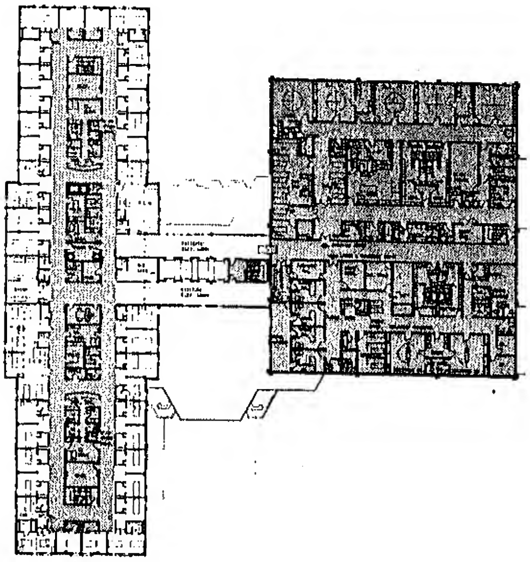


Figure 10. Public shelter areas on second floor.

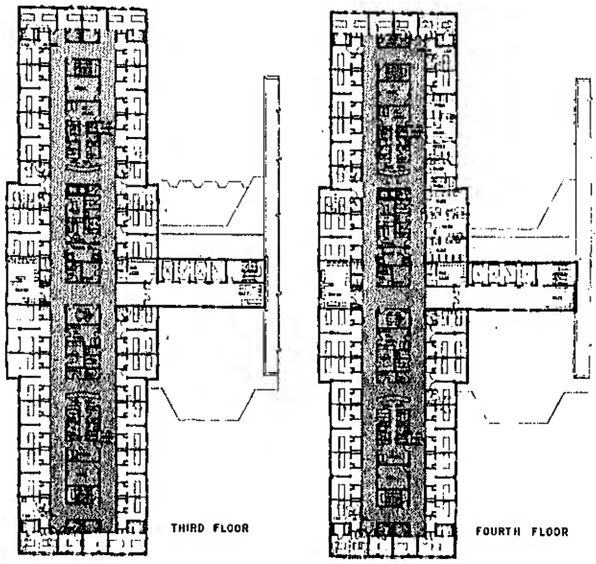


Figure 11. Public shelter areas on third and fourth floors.

act without delay and should be able to provide shelter for the maximum number of individuals within the hospital at the time of an alert. The peak population of a 180-bed general hospital is estimated to be 393, including patients, doctors, nurses, and staff. The hospital shelter area shown will house twice this many people. Therefore, ample space is available to shelter off-duty staff and other medical personnel from surrounding areas.

Shelter space not considered adequate for hospital shelter purposes should be developed as public shelter space and made available to the community at large. The public shelter space shown on figures 9, 10, and 11 will house about 3,800 people. The criteria for public shelter space are given in the OCD publication TM-61-3, Technical Requirements for Public Fallout Shelters.

By utilizing the principles outlined in this study, any degree of protection from fallout radiation commensurate with the community's civil defense plan can be incorporated in the hospital design. The shielding requirements for a particular hospital should be evaluated by the local authorities on the basis of its location with respect to probable target areas, directions of prevailing winds, potential for evacuation, and similar civil defense considerations.

Figure 12 shows the radiation protection factor required to shield out various percentages of fallout radiation. The graph shows that a protection factor as low as 2 will give 50 percent protection from fallout radiation and a protection factor of 100 will give 99 percent protection.

For this project, the minimum recommended radiation protection factor of 100 was adopted for the clinical services unit. To achieve this level of protection, the exterior wall construction for the first story should be equivalent to a mass thickness of 190 pounds per square foot (psf). "Mass thickness," as used here, is defined as the weight per square foot of surface. Other building elements would be of normal construction pro-

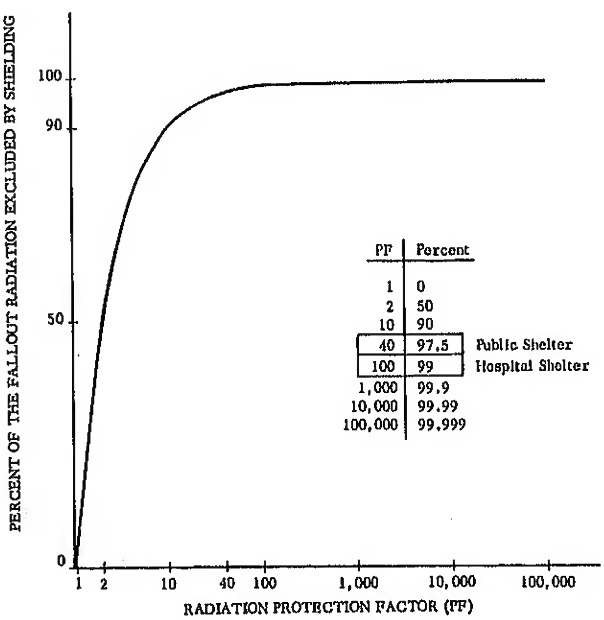


Figure 12. Relationship of radiation protection factor to percentage of effective shielding from fallout gamma radiation. (See Appendix for definition of protection factor.)

viding a mass thickness of approximately 120 psf for the second story walls, 70 psf for the roof, 25 psf for interior partitions, and 50 psf for the floors.

The patient unit of conventional construction has exterior walls equivalent to a mass thickness of 89 psf; roof, 70 psf; floors, 50 psf; and interior partitions, 53 psf. This will provide a minimum protection factor of 40 for the public shelter areas.

To design the shielding adequately, the architect should meet OCD qualifications for a Fallout Shelter Analyst or have someone on his staff or among the consultants who is qualified. If he wishes to determine who in his area has this capability, he may obtain a directory of qualified analysts from OCD. He may also wish to make use of the advisory service available through OCD at no cost.

A vital factor in obtaining a reasonable uniform shielding value throughout the hospital shelter area is to pay particular attention to placement and size of openings. For this reason, this area is practically windowless and contains as few doors and openings as possible. Doors, windows, stair towers, elevator shafts, and similar large openings are difficult to protect efficiently. A circuitous entrance pattern or maze will reduce radiation streaming in, but it may inhibit normal traffic flow. Temporary baffle walls of loose blocks or sandbags, which are put in place during the emergency period, are recommended when permanent baffles are not practical. For this project, permanent baffle walls are designed to give adequate shielding without any interference with normal traffic flow.

Elevator and stair shafts are removed from the hospital shelter areas without sacrificing vital hospital functions, thereby eliminating the need for any protective measures for these elements.

Because the dietary department, including food storage, is in the hospital shelter area, all food reserves in the hospital at the beginning of the alert would be available during the civil defense emergency. Under an average hospital's routine purchasing policy, this stock of food supplies rationed to the hospital shelter occupants at subsistance levels might last as long as a week. This means that, for disaster conditions, prepackaged food rations would then have to be furnished only for another week. It is expected that cooking could be kept to a minimum, being limited to soups and beverages warmed on electric cooking appliances. If sufficient water is not available for dishwashing purposes, single service paper plates and cups will be required.

ELECTRIC POWER

Electric service for a protected hospital of the type described herein operates in the same manner as for an ordinary hospital facility. Because an occasional interruption of the electric utility service is expected during the normal course of time and events, an emergency electric service usually of limited capacity is required for all hospitals to assure continuity of critical functions within the facility. The capacity of the emergency electric generating facilities provided for normal hospital operation will be of such size that no additional emergency power generating facilities should be required solely for shelter use.

For this particular design, the emergency power capacity required for the operation of essential equipment in the hospital shelter alone under fallout emergency conditions is estimated to be 285 kilowatts. This is equal to the estimated required kilowatt capacity needed for the total facility during an ordinary short-time interruption of the normal utility service.

The schematic wiring arrangement shown in figure 13 may be used to provide the necessary degree of flexibility in adapting a normal hospital electrical system for optimum use in a fallout emergency. It is recommended that the emergency circuits for lighting and equipment that must be automatically connected during a normal short-time power interruption be supplied through the Emergency Electrical System.

The remaining essential circuits in these areas that need to be energized during short-time normal interruptions of power may be supplied through the Critical Electrical System.

Circuits to lighting and equipment items considered necessary for use in a fallout emergency should be connected through the Optional Critical Electrical System.

Although these circuits may be supplied through a single transfer switch, it is generally recommended that they be supplied through two transfer switches--one for the nursing unit and one for the clinical services unit.

This hospital is divided into several principal sections and the emergency electric service is distributed throughout each section as required. During the fallout emergency condition, the emergency service may be manually disconnected from all sections except those designated as the hospital shelter. The emergency electric capacity could then be applied to operate the necessary additional equipment in the hospital shelter that is not emergency-operated during an ordinary short-time interruption of the normal utility service.

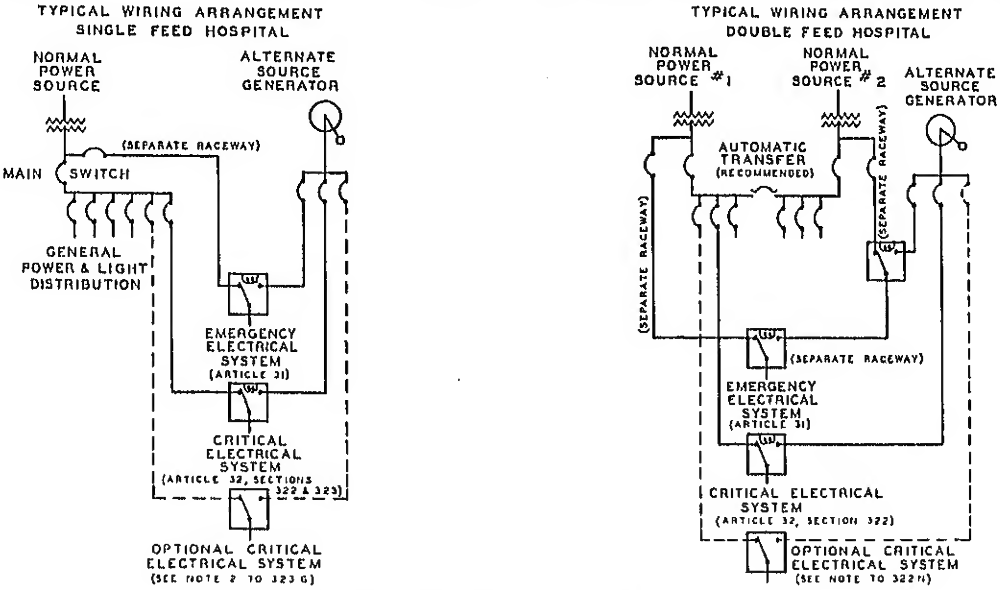


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Figure 13. Typical hospital wiring arrangements.

MECHANICAL SYSTEMS

The primary consideration in the design of the mechanical systems is to provide for the normal requirements of the hospital and to incorporate those features necessary to accommodate the fallout shelter conditions resulting from a nuclear explosion. To accomplish this, only slight deviations from the conventional designs of several systems in the hospital shelter are required. These deviations in no way detract from normal service and in some respects improve the service.

The utilities and services discussed in this section are: Plumbing, water supply, fire protection, heating, air conditioning and ventilation, and refuse and garbage disposal. As previously described, the hospital is divided into several sections, of which one would serve as a hospital shelter area and one would provide space that may be used as a public shelter. No special design considerations are involved in the areas to be used for public shelter.

Plumbing

The plumbing system is designed for normal hospital operation with the assumption that a public sanitary and storm sewerage system and a public water supply are available and would continue in operation during the fallout period.

The number and type of plumbing fixtures used are those which would be designed for service on the basis of normal hospital operation. If the water supply is insufficient to permit the use of all the standard fixtures, chemical toilets will be required. The waste from chemical toilets may be disposed of through the plumbing fixtures which are retained in operation. The plumbing fixture requirements for these shelter areas shall be as defined in the appendix. Bathing facilities are not considered a minimum requirement, but shower facilities in the shelter area are highly desirable. One shower bath for each 60 patients and one for

each 120 nonpatients is recommended. If the number of regularly installed shower baths is insufficient to meet the recommendation, additional shower facilities can be provided by installing a hose bib and shower head in each janitor's closet over the floor-type receptor which can serve as the drain.

Water Supply

The design of the water distribution system in the building is conventional and is supplied by two services from public water mains and a house tank. A house tank is considered desirable in a hospital facility to ensure continuity of service during breakdowns and for fire protection. If the sources of public water supply are rendered unavailable, the house tank will provide an emergency domestic water supply.

Ground water which is readily available from wells in many areas, may offer an unqualified solution to the problem of water supply in a fallout emergency. In addition to water for drinking, cooking, and sanitary purposes, the well should provide sufficient water for cooling the air-conditioning equipment and the emergency electric generator prime mover. The amount of water required for cooling this equipment will vary according to climatic and other design conditions. If ground water is not available, air-cooled condensers may be used for cooling the equipment.

Where well water is available, but not suitable for human consumption, the water may be utilized only for sanitary and cooling purposes.

According to code requirements, private well systems cannot be connected to the normal distribution system served by a public water supply. In this project, a pneumatic system is used with the well and provision is made for connecting the two systems quickly at the time of emergency. This connection consists of a spool piece which can be inserted between blank flanges provided in each of the systems.

As a precautionary measure, a water line independent of the normal distribution system should be installed from the storage tank to a point convenient for rationing if the normal water supply becomes limited during the fallout emergency.

Heating

To facilitate the maintenance and operation of the equipment housed in the boiler room, large window and door openings which may create a hazard during fallout should be avoided. Because of the construction characteristics and its relatively high density population, space heating needs for the hospital shelter will be limited to the tempering of ventilation air during extreme winter conditions. It is assumed that the hospital functions during the emergency will be minimal, involving only care of the patients, necessary surgery, and deliveries. As a result, sterilizing requirements will be quite small and may be handled by an electric sterilizer supplemented by the routine sterilizers, if needed.

Air Conditioning and Ventilation

The air components for physical comfort and well being with which we are primarily concerned, especially in a shelter having a high occupancy are: oxygen, carbon dioxide, and water vapor. However, consideration also should be given to odorous and pathogenic contaminants that occur in hospital occupancies.

Suitable levels of oxygen and carbon dioxide must be maintained at all times in the protected area. Based on the necessary activity in a hospital shelter, an estimated average of 0.9 cubic feet of carbon dioxide would be produced every hour by each occupant. An atmospheric concentration of 3 percent carbon dioxide is the maximum that a healthy person can tolerate without physical strain. Such concentrations could be disastrous to some hospital patients.

Suitable levels of oxygen and carbon dioxide are best maintained by the introduction of fresh outdoor air into the area by means of air conditioning. Minimum outdoor air ventilation rates to maintain proper levels of oxygen and carbon dioxide are dependent upon the per capita space allotment of the area involved. Because of the physical condition of many of the occupants of a hospital shelter and because of the ventilation requirements for certain clinical areas that may be active during an emergency, a minimum rate of 7 cubic feet per minute per person is required for hospital shelters. This ventilation rate provides for some odor control and also assists in maintaining sufficient air pressure within the protected area to minimize the infiltration of contaminated outdoor air.

Temperature and humidity must be maintained within reasonable comfort levels, particularly for the benefit of hospital patients. Effective

temperature, which is an arbitrary index representing the effect of warmth or cold felt by the human body is the best available index of ambient atmospheric conditions in relation to the physiological response of man. An effective temperature not to exceed 70^{o} is recommended for hospital shelter areas. This provides a range of temperatures and humidities somewhat above normal design practice for comfort, but well within tolerable limits.

Because of the construction characteristics of shelters, the population density anticipated, and the physical condition of many occupants, year-round air conditioning will be necessary for the hospital shelter areas.

Design Features

The air-conditioning system consists of water chillers with cooling towers located in the elevator penthouse. Individual conditioning units consisting of a fan and filter; preheat, cooling, and reheat coils; and a humidifier are used for each hospital department. In the clinical services unit, only one outdoor air inlet is provided. It is located in the right sidewall of the clinical services unit above the protected entrance rather on the roof to minimize the possibility of entraining contamination in the supply air. (See fig. 14.)

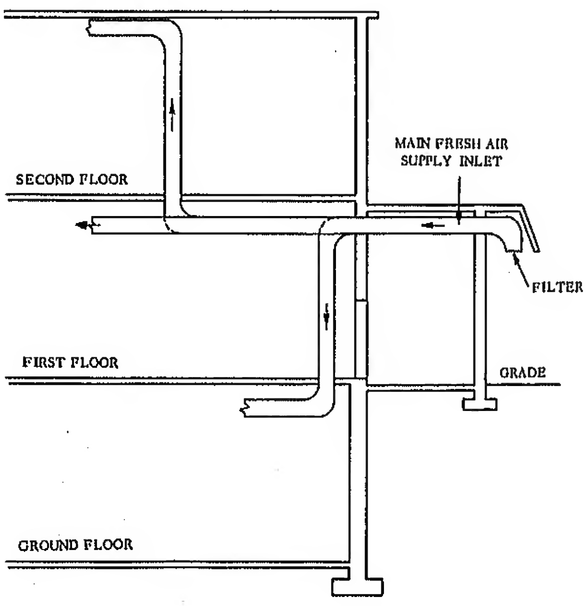

Figure 14. Detail of main fresh air supply inlet for clinical services unit.

This outdoor air is filtered at the main air intake duct to remove gross particulates before it is delivered to the individual conditioning units. The filters used in each of the individual units for final filtering purposes are selected according to the air quality required by the department served. For example, the units serving the operating, delivery, and recovery rooms require filters with an efficiency of 95 percent according to the dioctyl-phthalate (DOP) test method. Such areas as the laundry and the waiting room in the outpatient department are amply served by medium grade filters with efficiencies of 60 to 90 percent according to the National Bureau of Standards Dust Spot Test Method with atmospheric dust.

All duct systems are equipped with modulating dampers that permit a predetermined amount of outdoor and recirculated air to each department during normal hospital operation (fig. 15). This also applies to the operating and delivery rooms where recirculation of air is permitted when these rooms are not in use (fig. 16). In addition, these dampers are so arranged that they can be reset from a central control point to deliver only the predetermined quantity of fresh air allotted to each area during the fallout emergency.

Because there is ample head room above the finished ceilings, the conditioning units are housed on large platforms in this space. Sufficient space must be provided in this room for personnel to service the equipment from all sides. Without this head room these units would have been located in an equipment room in each area. The use of individual conditioning units is considered good design for hospital systems and adequately fulfills the emergency protection requirements. Individual units have several advantages: (1) greater flexibility of use can be provided; (2) control systems are less complicated; (3) temperature fluctuation in transmission from the equipment to the conditioned area is reduced; and (4) only one area is affected by a breakdown in equipment.

Each department is served by an individual exhaust fan that operates in conjunction with the department air-supply units to maintain a proper air balance. In the surgical and obstetrical suites, not more than two operating or delivery rooms should be served by one conditioning unit to provide versatility when these areas are used part time during normal operation. All exhaust fans are located on the roof. This arrangement provides a negative pressure in the exhaust duct system within the hospital building.

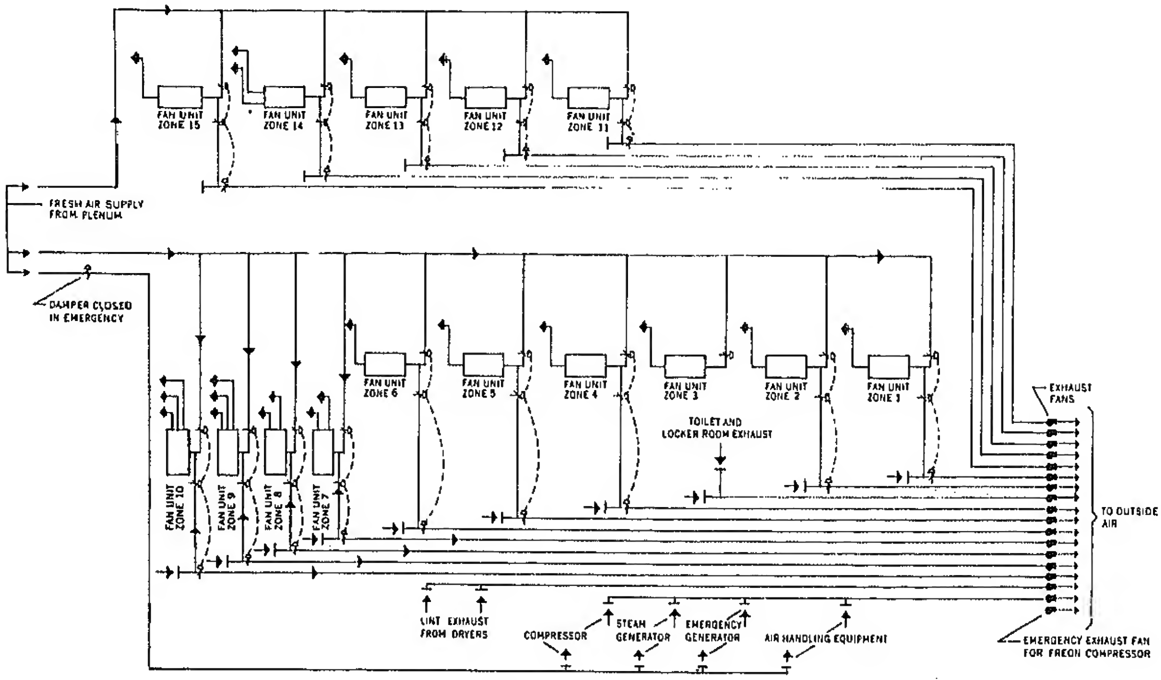

Figure 15. Ventilating and air conditioning flow diagrams.

Under disaster emergency conditions when the outdoor air is limited to 7 cubic feet per person per minute in the hospital shelter area, the quantity of air mechanically exhausted would be reduced to maintain a proper balance between supply and exhaust within the area. To accomplish this, all exhaust fans except those serving the toilet rooms, locker rooms, and autopsy suite would be turned off. Barometric controls for emergency use are installed on the exhaust fans that remain in operation. These controls are set to maintain a positive pressure within the shelter area during the emergency period. The morgue and autopsy area, as previously noted, is available for use as a decontamination area. The passageway through this area is already compartmentalized and provides a barrier between the shelter area and the outdoors. A fan having a 400 cubic foot per minute capacity is installed above the door that leads into the morgue area.

In the nursing unit areas, the perimeter rooms are each served by individual room units, located under the window, which circulate the air within each room. The ventilation air for the perimeter rooms and the air for ventilation and cooling of the interior rooms is provided by air handling equipment located in the two mechanical rooms on each floor. The use of this system avoids the possible hazard that might result from the use of individual room units which draw ventilation air through the walls from the outdoors.

The cooling requirements of this system are provided by the central water chiller.

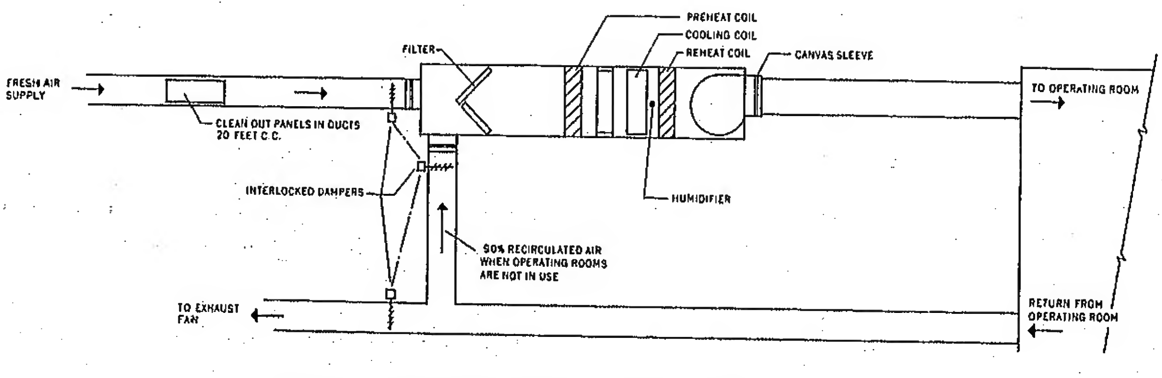

Figure 16. Air conditioning for operating rooms: schematic arrangement of air-handling unit, controls, and duct system.

Refuse and Garbage Disposal

Provision for the disposal of refuse and garbage must be carefully planned. Garbage, heavy cartons, bottles, and cans pose the greatest problem. Where an ample supply of water is available, garbage grinders are effective for food waste disposal. An incinerator solely for civil defense purposes is not recommended because it involves duplication of other available equipment, requires considerable combustion air, and does not dispose of bottles and cans. In this project, the autopsy room is used as a rubbish storage room. This room is selected because it will not be in use, is located away from the normal circulation area of the shelter, and is convenient to an exit. Periodically, the accumulation of waste can be removed to the outside, if necessary.

Fire Protection

Fire protection methods are conventional, consisting of a standpipe system and hose stations, generally supplemented with water-type fire extinguishers. Carbon dioxide extinguishers are provided in the boiler room, operating and delivery suites, emergency generator room, switch gear room, kitchen, and laundry. If the water supply is safe and adequate, the standpipe would be kept active during the emergency period; otherwise, fire protection would depend upon the available supply of fire extinguishers. A sprinkler system is required in the windowless area.

COST OF PROTECTION FOR PROTOTYPE HOSPITAL

A major objective of this study is to demonstrate that protective measures against fallout can be incorporated in the planning and design of hospital buildings at reasonable cost. Detailed cost figures for many items cannot be definitely established in a study where comparative costs are determined without benefit of actual contract prices. However, to establish some measure of the cost for fallout protection, an estimate was made of the additional cost of providing the shelter requirements for the prototype hospital described in this publication. These estimates were based on early 1967 costs in the New York City area and could be converted to approximate costs in other geographical areas by using an appropriate comparative building cost index.

Structural	$14,350
Concrete in lieu of masonry as back-up material in first story walls of clinical services unit	
Electrical	585
Additional transfer switches and accessories	
Plumbing	5,545
Deep well, valves, fittings, pipes, and accessories	
Air Conditioning	3,600
Additional dampers, controls, etc.	
Cost of providing PF100 shelter area in 180-bed prototype hospital	$24,080

From these figures, it can be seen that the cost of incorporating the radiation-fallout protection measures is certainly reasonable for the benefits obtained.

The low additional cost can be attributed to the following factors:

(1) Little additional space is required solely for protective purposes. Only space for the storage of emergency supplies (food, cots, communications equipment, and similar items), would be in excess of that required for normal hospital functions.

(2) Little additional equipment is required solely for protective purposes because a hospital is well supplied by mechanical and electrical equipment that is readily convertible for shelter use.

(3) The hospital areas involved permit a high degree of efficiency for providing maximum shelter capability.

PROTECTED ADDITION TO AN EXISTING HOSPITAL

A satisfactory nationwide program of protected health facilities obviously cannot be achieved in a reasonable time by the construction of new protected hospitals. Therefore, the role of the existing hospital becomes very important. Various methods of applying the principles of protective construction for the maximum benefit of existing hospital plants were studied.

Because of the type of construction, age of the buildings, and other factors, a 100 PF hospital shelter may prove difficult to achieve in some existing facilities with any degree of success, either functionally or economically. It would be possible, however, to plan a protected addition to an existing hospital by using the data developed for the prototype hospital described.

The planning requirements for each addition would vary with each hospital; therefore, specific planning recommendations are difficult to establish. Whether an addition could be designed with all the requisites for fallout protection with the same efficiency as a new hospital would depend on the kinds of services to be located in the addition. Some hospital services are not readily adaptable to shelter use; where such services must be located in a protected addition, it is obvious that a low degree of shelter efficiency will result. In some instances, the need for shelter space may exceed the space available in the addition. In this case, areas such as meeting rooms and training facilities, which usually are difficult to justify on a hospital's budget, might be acceptable when designed to be used in connection with the shelter program.

The services selected for inclusion in the prototype addition to an existing 180-bed general hospital are those commonly lacking or those which have outgrown available space in many hospitals. The areas that house these services are also highly adaptable to shelter use, and because of this, the protected unit is probably as small as can be devised. In all probability, if other types of hospital services are used, a larger area will result.

The plan for this addition is a windowless structure of one story above grade and a full basement. The first floor contains a rather complete outpatient department and a physical therapy department. The basement contains several meeting and instruction rooms, an occupational therapy room, mechanical equipment room, and storage facilities for the civil defense supplies and equipment. (See figs. 17, 18, 19.) The shielding, sleeping, electrical, and mechanical features of the protected addition are essentially similar to those discussed in the prototype fallout-protected hospital.

To provide minimum recommended radiation protection factor of 100 for the addition, a mass thickness of 225 psf should be used for the exterior wall construction and 155 psf for the roof. All other construction, such as partitions and floors, should be of normal type. The estimate of additional cost for providing this degree of shelter is as follows:

Structural	$10,500
Concrete in lieu of masonry as back-up material in walls	
Plumbing	5,545
Deep well, valves, fittings, pipes, and accessories	
Cost of providing shelter requirements in hospital addition	$16,045

NATURAL DISASTERS

In considering the design of the hospital for radiation protection, the architect should also take advantage of the opportunity to add protection against natural disasters. Increasing wall and floor thicknesses to provide shielding will afford opportunities to design for added protection against such hazards as tornadoes, hurricanes, earthquakes, and floods. Incorporation of features to assure protection against natural disasters will increase the serviceability and usefulness of the hospital facility and assure continuity of operation under disaster conditions. These safety features will add little, if any, to the construction costs.

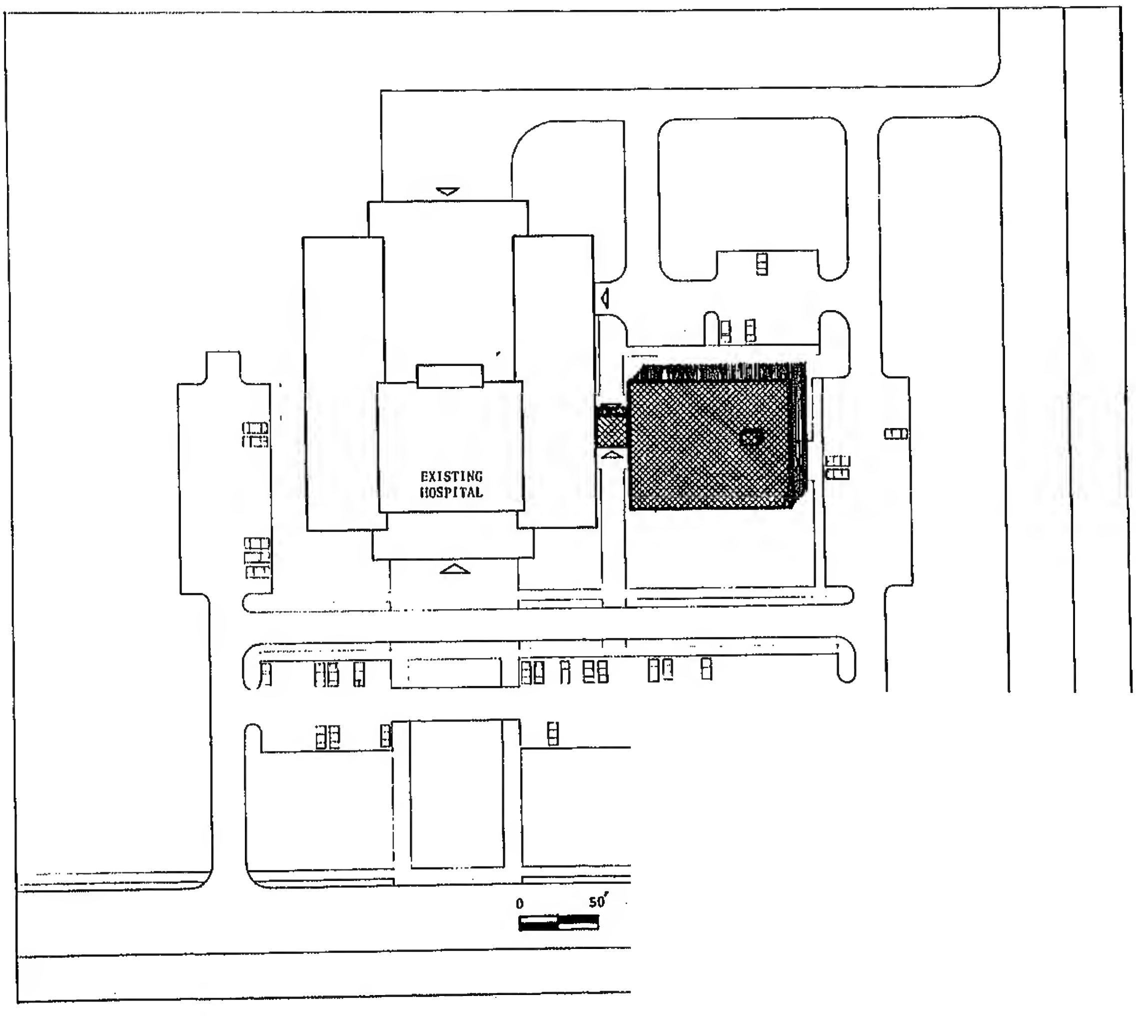

Figure 17. Site plan — additio

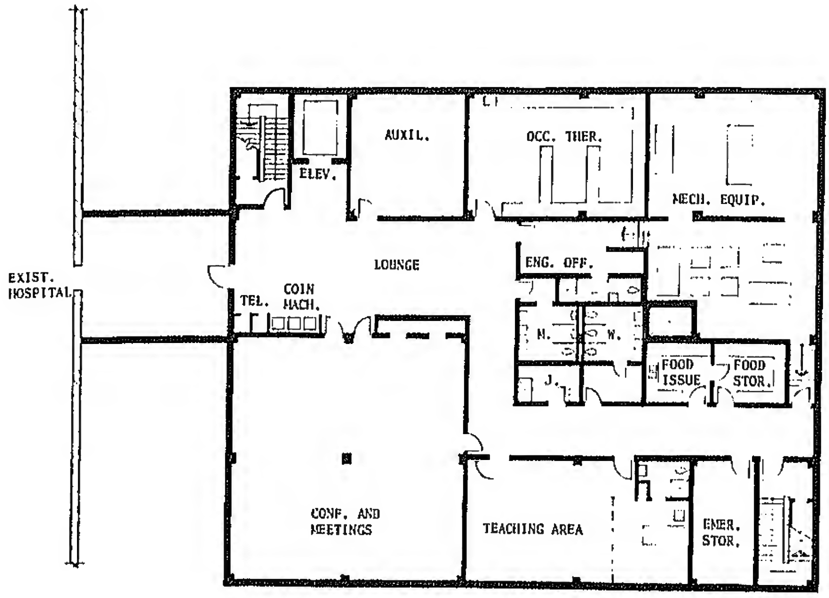

Figure 18. Ground floor addition to existing hospital.

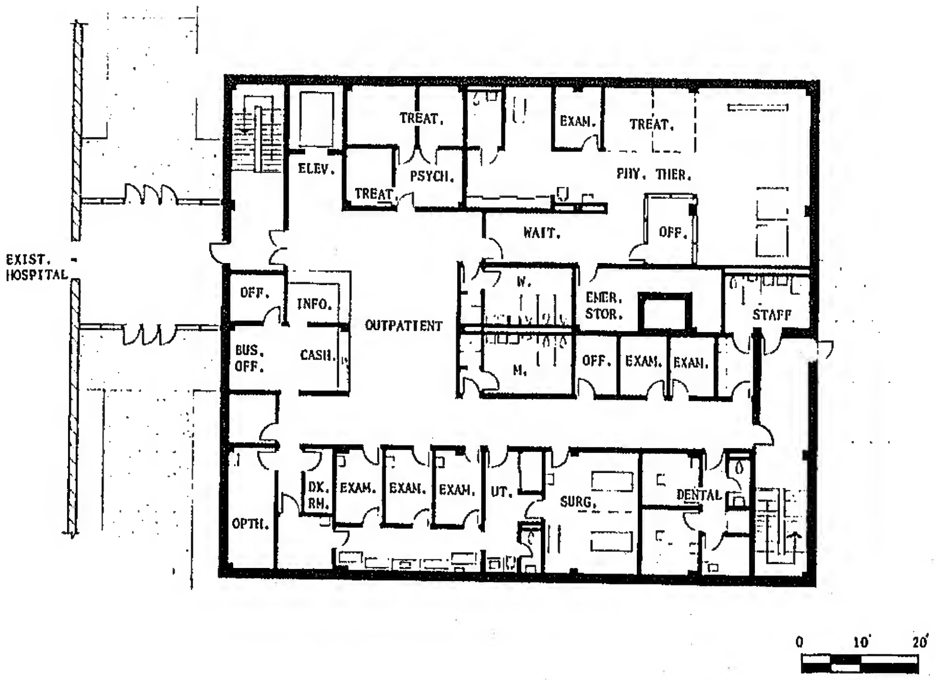

Figure 19. First floor addition to existing hospital.

APPENDIX

Office of Civil Defense
Department of the Army
Office of the Secretary of the Army
Washington, D. C. 20310

Architectural and Engineering Services
Technical Memorandum 65-1
June 1965

TECHNICAL REQUIREMENTS FOR FALLOUT SHELTERS IN HOSPITALS

I. General

The purpose of this technical memorandum is to establish official standards for fallout shelters in hospitals. Shelters designed under the provisions of this memorandum should be capable of functioning in a fallout environment as an operating medical facility by furnishing austere medical care for in-patients and providing emergency treatment as required.

II. Qualifications

The shelter area to be used for austere hospital services should include shielded space for all patients, and facilities needed for a minimum level of nursing care, and if space is available, a room reserved for emergency treatment, and one or more rooms for medical isolation purposes. This area may also provide the shelter space required for the complete Hospital Shelter area which would include shelter for patient care staff, food preparation facilities and a Control Center. All available shelter space in excess of that needed to provide austere hospital services and care for the patient population should be developed for public use. Hospital planning staffs should be encouraged to provide as large a shelter area as is economically possible.

III. Terminology

A. Protection Factor A factor used to express the relation between the amount of fallout gamma radiation that would be received by an unprotected person and the amount that would be received by one in a shelter. For example, an occupant of a shelter with a PF of 40 would be exposed to a dose rate 1/40 (2 1/2%) of the rate to which he would be exposed if his location were unprotected.

B. Fallout Shelter A structure, room or space that protects its occupants from fallout gamma radiation, with a protection factor of at least 40.

C. Austere Hospital Service Area Hospital area(s) which will serve as shelter for patients and patient care staff. Also includes area(s) where hospital services (including emergency surgery) will be performed. Protection factor in the Austere Hospital Service Area should be at least PF 100.

D. Public Fallout Shelter Area That shelter space designated for use by non-patient care employees, hospital visitors and general public.

E. Control Center The command post or operations headquarters within the Austere Hospital Service Area for use by the hospital administrator and his staff during an emergency. The supervision of all activities and personnel, not strictly under medical or surgical direction, will be conducted from this center by the hospital administrator.

IV. Radiation Shielding

A. Computation of protection factors shall be made by methods acceptable to the Office of Civil Defense. As it is anticipated that personnel with emergency functions may have to expose themselves to dangerous radiation levels during the performance of their duties, it is desirable to obtain the best possible protection factors for hospital staff with an acceptable minimum objective of at least PF 100.

B. In the calculation of the protection factor, the radiation dose contribution to the shelter occupants coming from the entranceways, ventilation ducts or other openings in the shelter's barriers shall be considered.

V. Public Shelter Areas

Technical criteria for shelter spaces designated as Public Fallout Shelter Areas should be in accordance with TM 61-3 (Revised), "Technical Requirements for Fallout Shelters."

VI. Space and Ventilation Requirements for Austere Hospital Service Area

A. Patient Area Requirements Thirty-five square feet per patient (based on nominal bed capacity) should be allocated for ward and treatment rooms reserved exclusively for patient (as contrasted to staff or public) use.

B. Patient Care Staff Space Requirements Fifteen square feet per employee engaged in patient care (e.g., physicians and nurses) should be allocated for staff quarters. This should be separated from public shelter areas.

C. Access and Egress One or more entranceways to the Austere Hospital Service Area should be at least 40 inches wide to permit passage of hospital beds.

D. Corridors and Aisles Minimum six foot width passageways should be provided for shelter traffic required in patient care and other emergency hospital operations.

E. Ventilation Provision should be made to prevent the build-up of vitiated air in shelters to a level hazardous to its occupants. Temperatures in the Austere Hospital Service Area should not exceed 70° Effective Temperature (ET).

F. Filters No special filters other than those used in normal hospital operations are necessary.

G. Fresh Air A minimum of 7 cfm of fresh air per person should be supplied to the Austere Hospital Service Area.

H. Air Conditioning Air conditioning will be required to provide suitable environmental conditions in operating rooms in all geographical areas. Provision should be made to supply emergency electrical service for this purpose.

I. Duct System Duct systems should be designed to permit the cut-off of unnecessary sections during an emergency.

J. Recirculation Air should not be recirculated from contagious wards, decontamination rooms, treatment rooms, toilets, chemical pits, or other areas which could contaminate the fresh air supply.

VII. Water Supply and Sanitation for Austere Hospital Service Area

A. Water Supply

1. Minimum Requirements A minimum of 5 gallons of water for each patient and ½ gallon per person for patient care staff must be available for daily consumption and use during the anticipated confinement. This may be accomplished through supply from storage tanks, wells and/or individual containers. The minimum requirements established herein are for all purposes including water for drinking, cooking, and sanitary purposes in addition to other water requirements.

2. Supply Lines and Outlets Supply lines from the emergency water source(s) (tank and/or well) to specific shelter areas should be provided. Outlets shall be available in the food preparation, medical treatment, decontamination, isolation, emergency operating, and other hospital service areas which may require an immediate water supply.

3. Treatment Hypochlorinator equipment and an adequate supply of high test calcium hypochlorite should be provided and used for treatment of nonpotable water from emergency sources. Water disinfectant tablets should be provided for treatment of water from therapeutic pools or other nonpotable sources.

4. Fire Protection When possible, standpipe systems should be cross-connected to emergency sources so that water will be available to the upper stories for fire fighting. However, standpipe systems should not be cross-connected to emergency water sources unless proper protection from such cross-connection hazards is provided in accordance with State Health Department regulations and approval.

B. Sanitation Provision should be made for the collection and disposal of garbage, trash and human waste in such a way as to preclude

the creation of unsanitary conditions or offensive odors. When emergency water supply permits, regular flush-type toilets and lavatories should be made available on the basis of one per 35 hospital staff or patients. (Chemical toilets should be made available as a supplement to regular toilets, or in lieu thereof, in case the system becomes inoperative).

VIII. Electrical

A. Hospital Emergency Electrical Power In the normal operation of a functional hospital, standby emergency power is a necessity to provide continuous service to critical areas with or without fallout protection. Hospitals are therefore normally equipped with stand-by power generators which can be used in an emergency under fallout conditions. It may be necessary to install additional wiring and switching controls to direct power to the Austere Hospital Service Area.

B. Minimum Service Disconnecting devices and switching gear should be provided to limit the power utilization of either the normal or emergency supply sources to essential requirements. Power should be made available to operate at least the following in the Austere Hospital Service Area.

1. Required shelter ventilation
2. Required lighting
3. Emergency water supply
4. Emergency sewage ejection
5. Medical and surgical treatment areas
6. Boiler feed water pump
7. Emergency refrigeration (Hospital Service Area)
8. Emergency air conditioning (Hospital Service Area)

C. Shielding The emergency generator sets and control and distribution panels should be in protected areas. Access to the engine, control rooms and distribution panel also should be shielded.

D. Illumination Lighting levels in the hospital service area should be as follows:

1. Treatment room: 100 foot candles at treatment table.
2. Patient areas (desk level): 25 foot candles.
3. Sleeping areas (floor level): 2 foot candles.

E. Outlets Emergency power outlets should be strategically located so that portable hospital equipment may be utilized where needed.

F. Venting Emergency engine-generator sets should have separate vents so that hospital equipment may be utilized where needed.

G. Fuel Storage Emergency engine-generator sets should have a storage tank for a minimum fuel supply sufficient for at least two weeks of continuous operation.

H. Battery-Operated Lights Trickle charged battery operated emergency lights should be distributed for use in corridors, hospital operating rooms, essential work areas and facilities in event of power failure.

IX. Emergency Supplies for Austere Hospital Service Area

A. General Where feasible, essential shelter supplies should be stored within the shelter areas or within easy access of those areas. Actual space required for this purpose will vary depending upon the type, location, and size of the hospital. As a minimum, space for food, water, radiation detection equipment, sanitary kits, bunks and other required furnishings or supplies should be considered in storage space determinations.

B. Food Storage A supply of canned foods of types appropriate for patient care and hospital staff is required for anticipated periods of confinement. The capacity of the general hospital food lockers and normal food storage areas should be investigated in any determination of space requirements.

C. Water Storage Wells, storage tanks and therapeutic pools should be considered for emergency water sources because the high requirement of patients and staff precludes total reliance on water containers. Minimum requirements should be calculated at the rate of 10 cu. ft. per patient and one cu. ft. for all other occupants.

D. Other Storage Consideration should be given to space requirements for small items such as radiation detection equipment, sanitary kits, hand basins, and chemical toilets. Determination of other storage space requirements must be calculated on an individual or local basis. In general, however, the design of hospital shelters requires much more storage than community or other type shelters. Storage areas for emergency supplies should be conducive to their protection. When crawl spaces are used for storage, items shall not be placed directly on the earth.

E. Sleeping Facilities Bunks or cots should be incorporated in the design of a dual purpose hospital shelter. Their storage may be outside the shelter areas prior to installation within the allotted shelter areas. Single bunks, cots or hospital beds are preferable for nonambulatory patients (about 10-25%); use is dependent upon space available.

X. Communications

A. Radio The hospital should have a radio transmitter, battery operated receivers and an installed antenna to permit contact between the control center and civil defense authorities.

B. Telephone Regular telephone service also should be used when in operation.

C. Intercommunications Provision should be made for communications to and from the control center and the main shelter areas by at least two of the following methods: telephone, intercom, selective channel public address system, or messenger.